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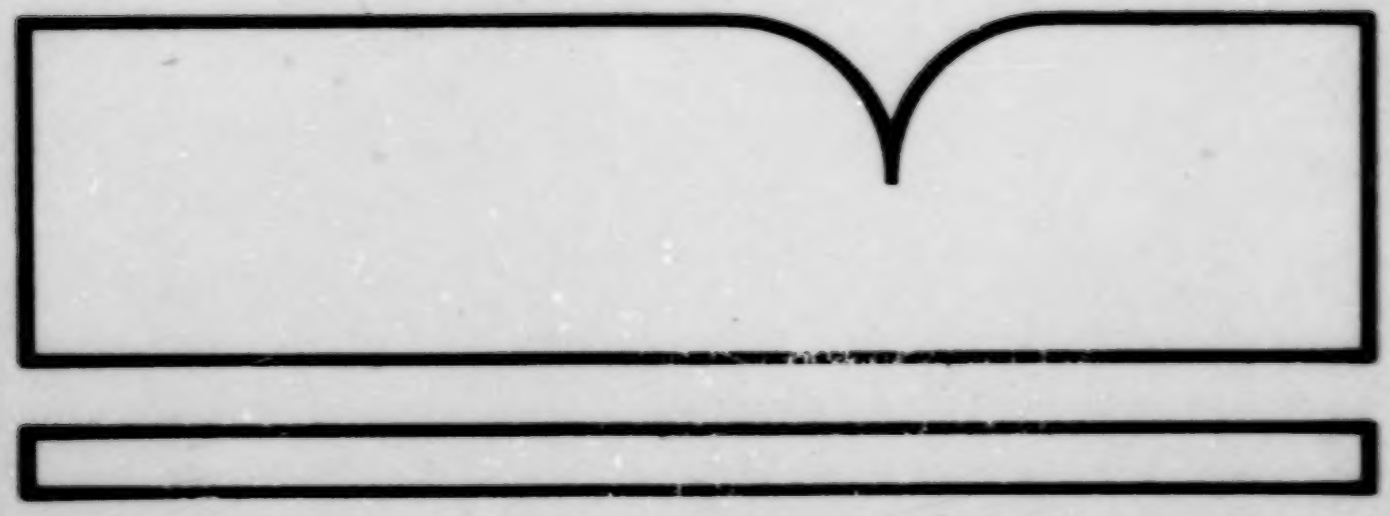
Evaporative Emissions of Methanol Blend Fueled Vehicles

Southwest Research Inst., San Antonio, TX

Prepared for

Environmental Protection Agency, Ann Arbor, MI

Nov 84



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16. ABSTRACT

This report describes evaporative emission tests that were conducted on a 14-vehicle Department of Energy (DOE) fleet currently under test at Southwest Research Institute. Seven vehicles were accumulating mileage on an unleaded control fuel and seven vehicles were accumulating mileage on an alcohol blend containing 4 percent methanol, 2 percent ethanol and 2 percent t-butyl alcohol (TBA). Alcohol speciation of evaporative emission hydrocarbons was conducted on selected tests using the alcohol-containing fuel. In addition, a "Matched blend" gasoline was prepared so that the front-end volatility index (FEVI) was equivalent to the FEVI of the control fuel.

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Technical Report

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Project Officer

Craig A. Harvey

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POST OFFICE DRAWER 28510 • 6220 CULEBRA ROAD • SAN ANTONIO, TEXAS, USA 78284 • (512) 684-5111 • TELEX 76-7357

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TO: Mr. Craig A. Harvey, Project Officer
Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, MI 48105

FROM: Harry E. Dietzmann
Department of Emissions Research
Southwest Research Institute
6220 Culebra Road
San Antonio, TX 78284

SUBJECT: Final Data Report on Tasks 1 and 2 of Work Assignment No. 4, Contract 68-03-3192, "Gasoline Volatility Analysis," SwRI Project 03-7774, Phases -104 and -204.

I. INTRODUCTION

This Work Assignment is made up of four individual Tasks, each of which has its own objectives. Task 1, "Matched Gasoline Preparation," is included to formulate test gasolines for use in Task 2, "Vehicle Evaporative Emission Testing." Task 2 uses a 14-car fleet under test for DOE to gain information on changes in evaporative emission performance due to the use of methanol blends. Task 3, "Vehicle Fuel Volatility Trends," is an attempt to determine how gasolines with a range of front-end volatilities "weather" in the fuel tank during normal consumer use. Task 4, "Gasoline Volatility Control Study," uses refinery modeling to determine the costs (to the refiner) associated with volatility control as a method to reduce evaporative emissions. The Final Data Report presents data and results of Tasks 1 and 2. Separate Final Data Reports will be submitted on Tasks 3 and 4.

II. SUMMARY

Evaporative emission tests were conducted on a 14-vehicle DOE fleet currently under test at SwRI. Seven vehicles were accumulating mileage on an unleaded control fuel (EM-601-F), and seven vehicles were accumulating mileage on an alcohol blend (EM-602-F) containing 4 percent methanol, 2 percent ethanol and 2 percent t-butyl alcohol (TBA). Alcohol speciation of evaporative emission hydrocarbons was conducted on selected tests using the alcohol-containing fuel. In addition, a "matched-blend" gasoline (EM-603-F) was prepared so that the front-end volatility index (FEVI) was equivalent to the FEVI of the control fuel.

Exhaust emissions data were not collected during the complete test matrix, but rather only on the DOE blend vehicles operating on the blend fuel, and the DOE control vehicle operating on the control fuel. The CO, HC, and NOx emission rates were quite close for the two vehicle-fuel combinations.

Based on the data generated in this study, the following items appear pertinent.

1. Hydrocarbon evaporative emissions of the blend vehicles tested on the control fuel averaged 5.55 g/test compared to 2.50 g/test for the control vehicles tested on the control fuel (EM-601-F).

2. Hydrocarbon evaporative emissions from the blend vehicles on the blend fuel (EM-602-F) increased significantly to 23.62 g/test for the seven vehicles. This is not surprising, since the RVP of the blend fuel (EM-602-F) was 12.3 psi compared to the RVP of 9.1 psi of the control fuel.

3. Evaporative emission testing of both vehicle groups with the matched blend fuel (EM-603-F) produced evaporative emissions only slightly higher than the 2.0 g/test for the control vehicles. Differences between the control vehicles tested on EM-601-F and EM-603-F (i.e., fuels with the same FEVI) showed essentially no difference in evaporative emissions, i.e., 2.50 g/test with EM-602-F compared to 2.23 g/test with EM-603-F. However, when the blend vehicles were tested with EM-601-F, evaporative emissions were 5.50 g/test compared to 2.37 g/test with the matched blend fuel, EM-603-F.

4. In general, methanol accounted for about four percent of the ppmC in the SHED evaporative emission tests. Ethanol generally accounted for less than one percent of the SHED ppmC and TBA accounted for less than 0.5 percent of the SHED ppmC.

III. RESULTS

A. Task 1 - Matched Blend preparation

Preparation of the "matched blend" gasoline (EM-603-F) has been completed and fuel inspection data are presented in Table 1. This fuel was prepared to have a front end volatility equivalent to the DOE unleaded control fuel (EM-601-F). Approximately 450 gallons of the "matched blend" fuel were prepared and about 200 gallons were used during the emission testing of the DOE vehicles under this work assignment, leaving about 250 gallons for testing at the end of the DOE vehicle mileage accumulation, scheduled for FY'85. It is anticipated that mileage accumulation on the DOE vehicles will be completed in late November.

TABLE 1. TASK 1 FUEL INSPECTION DATA[a]

Specification	ASTM	Fuel Code EM-601-F	EM-602-F	EM-603-F
API Gravity @ 60°F	D-287	59.5	58.8	---
Distillation, °F	D-86			
IBP		87	89	101
10%		119	111	125
50%		207	186	212
90%		341	336	339
EP		409	402	393
Recovery, %		98.0	98.0	98.0
Residue, %		1.0	1.0	1.0
Loss, %		1.0	1.0	1.0
% Evaporated @ 158°F		28.0	40.5	32.5
RVP, psig	D-323	9.1	12.3	8.6
Water, ppm	D-1533	158	587	---
V/L @ 20°F	D-439	137.3	119.9	---
Water tolerance[b]		---	pass	---
FEVI[c]		12.7	17.6	12.8

[a] Additional fuel inspection data will be included as they are received.

[b] ASTM information document on Gasohol, ASTM Section 5, Volume 05.01 (Appendix).

[c] Front end volatility index, FEVI = RVP +0.13 (% Evap @ 158°F)

The remaining 250 gallons are stored in securely sealed drums in a "cold box" until the vehicles are ready for testing. Sufficient quantities of the unleaded control fuel and alcohol blend have been drummed and are also stored for testing in November or December.

B. Task 2 - Vehicle Evaporative Emission Testing

Emission tests on the 14 DOE vehicles have been completed and results are presented in Table 2. All of the control fuel vehicles were tested first with the control fuel and then the matched blend. For five of the blend vehicles the test sequence was first the control fuel, then the DOE blend, and finally the matched blend. The other two blend vehicles (102 and 107) were tested first on the DOE blend, then the matched blend, and finally the control fuel. As can be seen from the odometer readings in Table 2, the mileage between each test ranged from a few hundred to a few thousand miles. All of the mileage accumulation was done by lending the vehicles to employees to use in their normal driving. As preconditioning prior to the start of the SHED test each vehicle was run on the test fuel using one LA-4 dynomometer driving cycle and overnight soak as in the standard EPA certification procedure.

Evaporative emission results for the DOE vehicles operating on three fuels are summarized in Figure 1. Total evaporative emissions of the seven DOE blend vehicles tested on the control fuel (5.55 g/test) were about double those from the seven DOE control vehicles (2.50 g/test). Most of this difference was due to the greater diurnal emissions of the blend vehicles, which was statistically significant at a 95 percent confidence level. When tested on the blend fuel (EM-602-F) the evaporative emissions of the seven DOE blend vehicles increased dramatically. An increase in evaporative emissions with EM-602-F is not unexpected, since the RVP of the fuel is 12.3 psi compared to the control fuel (EM-601-F) RVP of 9.1 psi. No significant difference in total evaporative emission results was observed when the blend and control vehicles were tested with the matched blend fuel, EM-603-F, but the diurnal emissions of the blend vehicles were significantly greater than the control vehicles at a 95 percent confidence level.

During the evaporative emission tests with the blend and matched blend fuels, samples were obtained to quantitatively determine the amount of methanol, ethanol and t-butyl alcohol (TBA) in selected SHED tests. These results are presented in Table 3. In general, methanol was the only alcohol to account for more than one percent of the total hydrocarbons

TABLE 2. EMISSIONS RESULTS FROM DOE VEHICLES

Fuel Code	Vehicle	Odometer	FTP Emission Rate g/mi CO	HC	NO_x	SHED Evap. HC, g Diurnal	Hot Soak	Total
EM-601-F	101	8,455	NR[a]	NR	NR	5.07	1.33	6.40
DOE	102	15,532	NR	NR	NR	2.32	1.50	3.82
Control	103	12,656	NR	NR	NR	5.72	1.79	7.51
Fuel	104	16,222	NR	NR	NR	3.19	1.27	4.46
	105	9,905	NR	NR	NR	1.73	4.24	5.97
	106	9,706	NR	NR	NR	0.95	1.36	2.31
	107	9,614	NR	NR	NR	6.92	1.44	8.36
	Avg	11,727				3.70	1.85	5.55
EM-601-F	201	10,269	2.99	0.32	0.57	0.92	0.980	1.90
DOE	202	14,934	3.65	0.33	0.47	2.80	1.36	4.16
Control	203	12,148	3.15	0.45	0.50	0.39	1.24	1.63
Fuel	204	15,451	5.37	0.62	0.52	0.34	1.30	1.64
	205	12,692	5.92	0.33	0.46	2.19	1.14	3.33
	206	11,346	3.05	0.40	0.70	0.27	1.24	1.51
	207	9,338	2.44	0.39	0.60	2.30	1.08	3.38
	Avg	12,311	3.80	0.41	0.55	1.31	1.19	2.50
EM-602-F	101	9,087	3.56	0.46	0.67	8.53	2.27	10.80
DOE	102	14,183	4.12	0.63	0.58	5.00	25.63	30.63
Blend	103	13,519	2.98	0.51	0.66	13.83	24.53	38.36
Fuel	104	16,516	4.57	0.56	0.49	12.45	26.61	39.06
	105	10,151	4.81	0.51	0.72	5.66	7.96	13.62
	106	9,914	1.75	0.41	1.09	4.75	3.82	8.39
	107	8,687	4.02	0.40	0.55	12.95	11.37	24.32
	Avg	11,722	3.68	0.48	0.68	9.02	14.60	23.62
EM-603-F	101	9,916	NR	NR	NR	0.47	1.51	1.98
EPA	102	15,265	NR	NR	NR	0.65	1.33	1.98
Matched	103	14,136	NR	NR	NR	0.54	1.01	1.55
Blend	104	17,326	NR	NR	NR	2.24	1.30	3.54
Fuel	105	11,165	NR	NR	NR	1.86	1.25	3.11
	106	11,205	NR	NR	NR	0.58	1.40	1.98
	107	9,236	NR	NR	NR	0.97	1.50	2.47
	Avg	12,607				1.04	1.33	2.37
EM-603-F	201	11,383	NR	NR	NR	0.34	1.50	1.83
EPA	202	16,138	NR	NR	NR	0.32	1.30	1.62
Matched	203	13,836	NR	NR	NR	0.27	2.06	2.34
Blend	204	17,815	NR	NR	NR	0.32	1.23	1.55
Fuel	205	16,397	NR	NR	NR	0.25	1.18	1.43
	206	12,742	NR	NR	NR	0.38	3.79	4.17
	207	10,765	NR	NR	NR	0.43	2.22	2.65
	Avg	14,154				0.33	1.90	2.23

[a] not run

Corrected

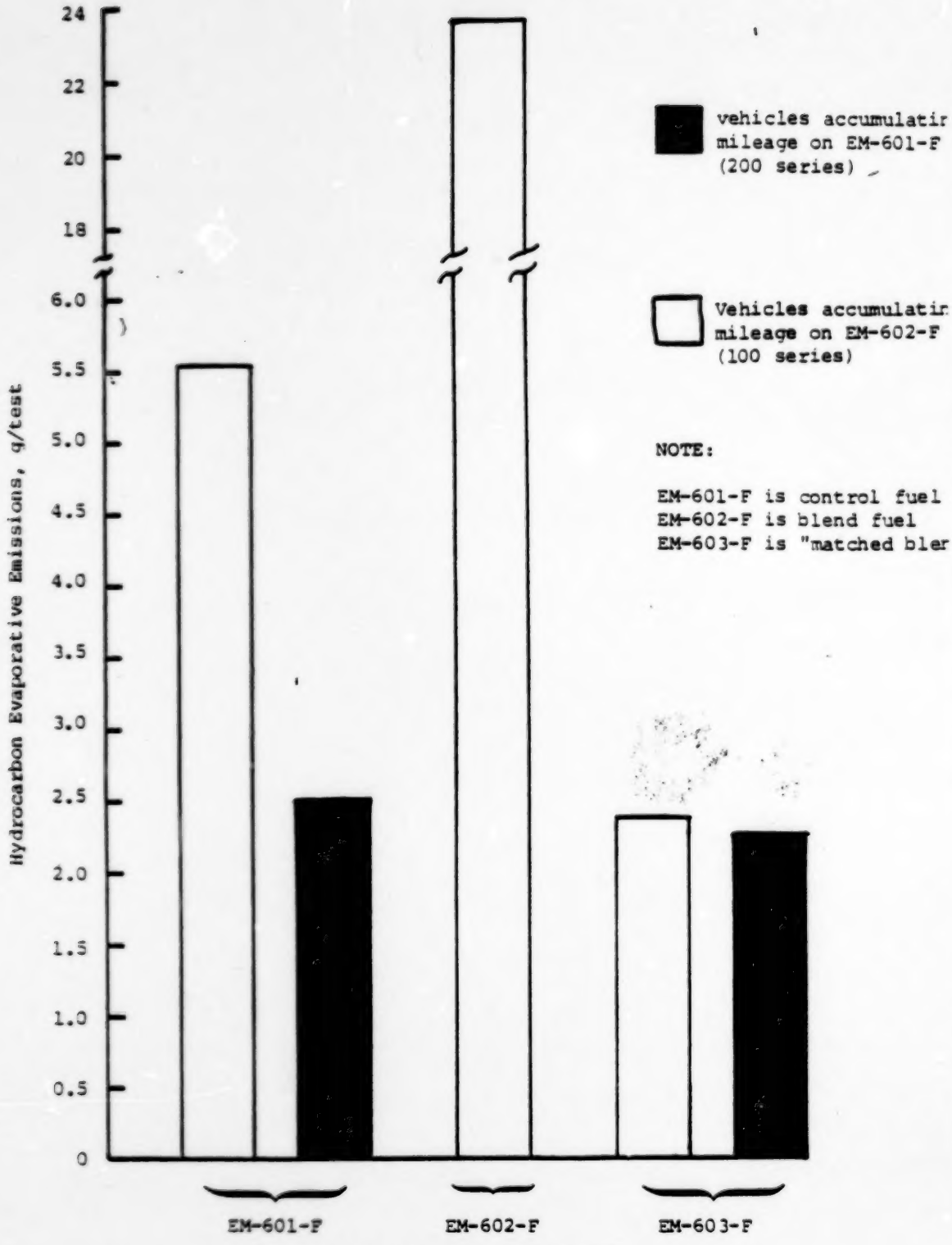

Figure 1. Comparison of Evaporative Emission Results from DOE vehicles tested with three fuels

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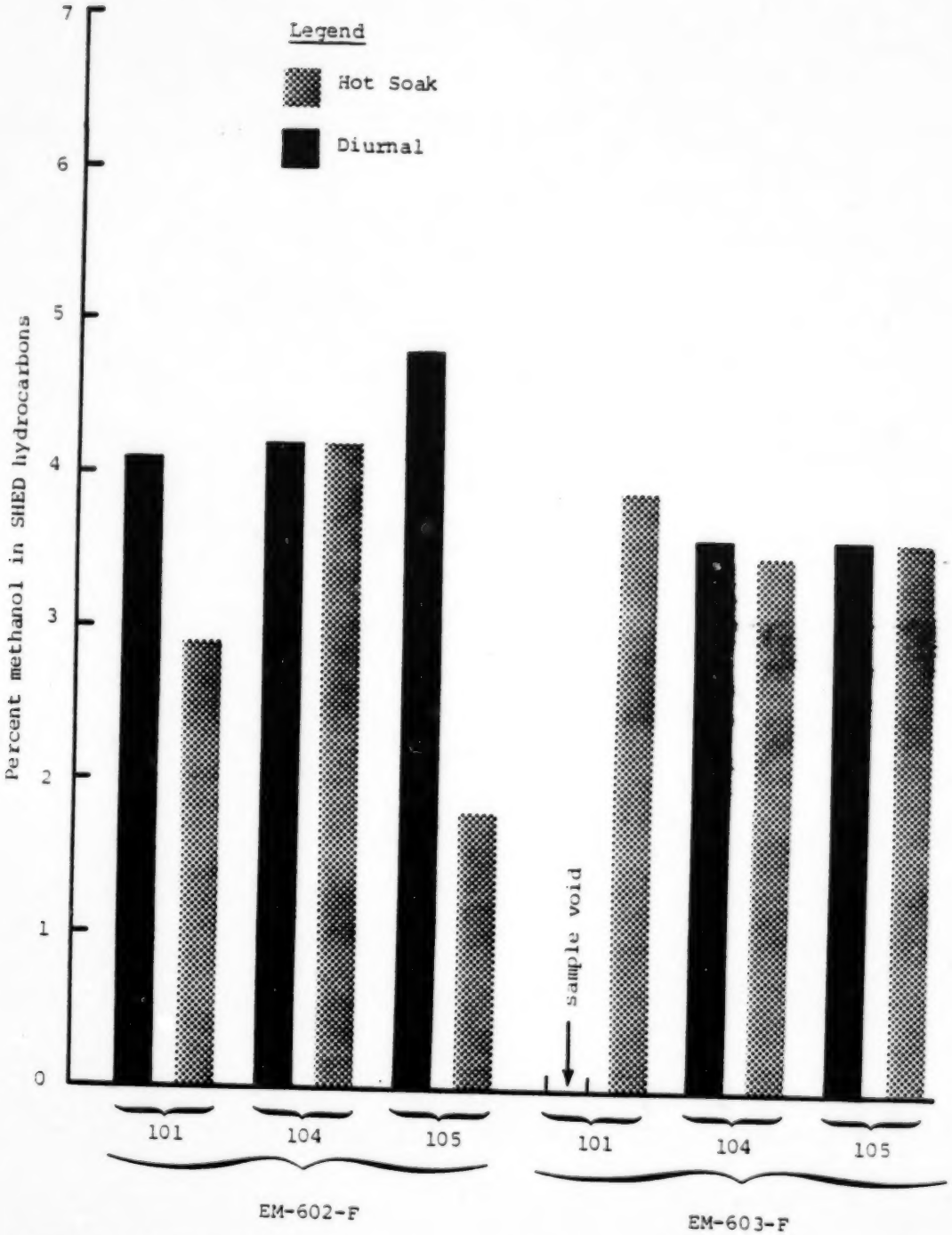

Figure 2. Comparison of percent methanol in SHED hydrocarbons from three DOE blend vehicles tested with two fuels (Blend, EM-602-F and matched blend, EM-603-F)

TABLE 3. ALCOHOL SPECIATION OF SHED HYDROCARBONS FROM THREE DOE BLEND VEHICLES OPERATING ON TWO FUELS

Vehicle	Alcohol Species	Conc.	EM-602-F Diurnal	EM-602-F Hot Soak	EM-602-F Background	EM-603-F Diurnal	EM-603-F Hot Soak	EM-603-F Background
104	CH_3OH	ppm	26.2	53.6	0.3	4.48	2.83	0.16
		ppmC	20.7	42.3	0.2	3.54	2.24	0.13
		µg/m³	34,958	71,451	362	5970	3870	252
		% THC	4.2	4.2	0.5	3.6	3.4	0.7
	C_2H_5OH	ppm	1.80	6.74	ND	0.55	0.37	0.01
		ppmC	3.1	11.4	ND	0.94	0.63	---
		µg/m³	3446	12,906	ND	1050	708	27.4
		% THC	0.6	1.1	ND	0.9	1.0	---
	TBA	ppm	0.44	2.65	ND	0.13	0.07	0.01
		ppmC	1.7	10.1	ND	0.50	0.27	0.04
		µg/m³	1369	8163	ND	393	224	34
		% THC	0.3	1.0	ND	0.5	0.4	0.2
105	CH_3OH	ppm	13.65	7.02	0.22	4.17	2.85	0.21
		ppmC	10.8	5.5	0.2	3.29	2.25	0.17
		µg/m³	18,191	9361	2177	5560	3790	278
		% THC	4.8	1.8	1.0	3.6	3.6	0.8
	C_2H_5OH	ppm	1.05	1.24	0.03	0.02	0.41	0.03
		ppmC	1.8	2.1	0.05	0.03	0.70	0.05
		µg/m³	2015	2378	48	39	775	65
		% THC	0.8	0.7	0.3	<0.1	1.1	0.2
	TBA	ppm	0.07	0.18	ND	0.04	0.07	ND
		ppmC	0.27	0.69	ND	0.15	0.27	ND
		µg/m³	196	480	ND	124	208	ND
		% THC	0.1	0.2	ND	0.2	0.4	ND
101	CH_3OH	ppm	17.26	3.64	0.50	VOID	3.14	0.13
		ppmC	13.6	2.9	0.4	VOID	2.5	0.10
		µg/m³	23,001	4852	662	VOID	4170	173
		% THC	4.1	2.9	0.2	VOID	3.9	0.8
	C_2H_5OH	ppm	1.36	0.79	0.05	0.05	ND	0.04
		ppmC	2.3	1.3	0.09	0.09	ND	0.07
		µg/m³	2598	1517	104	105	ND	71
		% THC	0.7	1.3	0.5	0.2	ND	0.4
	TBA	ppm	0.06	0.13	ND	ND	0.11	ND
		ppmC	0.23	0.50	ND	ND	0.42	ND
		µg/m³	148	361	ND	ND	339	ND
		% THC	0.1	0.5	ND	ND	0.6	ND

ND - not detected

in the evaporative emissions. The percent methanol in SHED evaporative emissions of the DOE vehicles was generally about 4 percent of the total hydrocarbons in the SHED, as illustrated in Figure 2. Methanol was blended at four percent, ethanol was blended at two percent, and TBA was blended at two percent. Ethanol averaged about 0.7 percent of the SHED hydrocarbons, while TBA accounted for less than 0.4 percent of the SHED hydrocarbons.

Prepared by:

Harry E. Dietzmann

Harry E. Dietzmann
Manager, Chemical Analysis
Department of Emissions Research

Reviewed by:

Charles T. Hare

Charles T. Hare
Manager, Advanced Technology
Department of Emissions Research

Submitted by:

Karl J. Springer

Karl J. Springer
Director
Department of Emissions Research